

NASA CR-134

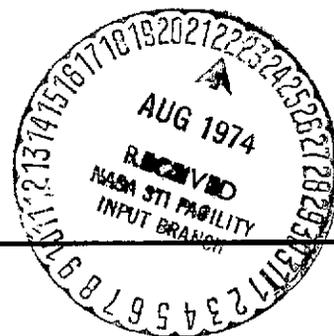
FINAL REPORT SPACE SHUTTLE/ FOOD SYSTEM STUDY VOLUME II

APPENDIX G
GROUND SUPPORT SYSTEM ANALYSIS

APPENDIX H
GALLEY FUNCTIONAL DETAILS ANALYSIS

prepared for
NATIONAL AERONAUTICS and SPACE ADMINISTRATION
Johnson Spacecraft Center
Houston, Texas 77058

Contract NAS9-13138



Prepared by



THE PILLSBURY CO.

(NASA-CR-134379) SPACE SHUTTLE/FOOD
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FAIRCHILD
REPUBLIC DIVISION

GROUND SUPPORT SYSTEM

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GROUND SUPPORT SYSTEM

1.0 Introduction

This report details the analysis of the facilities and capabilities of the Ground Support System of the Shuttle Food System. The Ground Support System serves the dual functions of pre-flight feeding of flight personnel and the supply and control of the flight food system. Twelve major elements of the Ground Support System have been identified as necessary to the efficient accomplishment of the system functions.

Administration

Dietetics

Analytical Labs

Flight Food Warehouse

Stowage Module Assembly Area

Launch-site Module Storage Area

Alert Crew Restaurant and Disperse Crew Galleys

Ground Food Warehouse

Manufacturing Facilities

Transport

Computer Support

These elements need not be physically separate, but may share the same facilities and/or personnel.

The majority of the operation of the Ground Food System will be at JSC, Texas. In addition there will be support facilities located at the Launch sites and major landing sites. There will also be mobile facilities to support the crewmen when at locations inconvenient to any of the permanent facilities.

1.0 Cont'd

The following assumptions and requirements have been incorporated into the analysis.

- 1) Baseline mission: 6 men - 7 days
- 2) 60 flights per year
- 3) Ground System Sizing - 40 consumers maximum
10 - 15 consumers minimum
- 4) Complete Nutritional Control
- 5) Real time, a la Carte choice from a large variety of food items.
- 6) 24 hour availability at all dining facilities
- 7) Support of Flight Food System
- 8) Training Facility for Flight Food System operation
- 9) Accomodate Foreign Nationals
- 10) High quality, Restaurant-like dining with table service at main dining facility.
- 11) Minimum meal preparation time.
- 12) Support alert crew at any location.

2.0 Discussion

2.1 Introduction

This report details an analysis of each functional element of the Ground Food System. The functions, capabilities and facilities of each element are presented. The design criteria are minimum cost and maximum flexibility, reliability and efficiency consistent with the requirements.

2.2 Administration

2.2.1 Functions

Administration serves the management function of the Ground Support System and interacts with the program management.

2.2.2 Capabilities

The Food System Administration must have the manpower and resources necessary to perform in the following areas.

- Keeping records and maintaining data files.

- Decision making and problem solving.

- Coordination of GSS Functional Elements.

- Responding to Program Management.

2.2.3 Facilities

Administration Facilities will consist of office space and computer terminals located at JSC, Texas, and tied in to all other GSS functional elements.

2.3 Dietetics

2.3.1 Functions

The Primary Function of Dietetics is to ensure the proper nutrition of all flight personnel. This includes both pre-flight and flight conditions.

Secondarily, dietetics supports the Food System in the areas of:

Menu Planning

Usage Management

Crew Training

Stowage Module Assembly Management

Standards and Requirements

Dietetics is in functional control of the working elements of the Ground Support System.

2.3.2 Capabilities

Dietetics must be capable of performing satisfactorily in the following areas.

Conducting Taste Tests

Constructing Menus

Monitoring and Planning Nutritional Intake

Providing Nutritional Countermeasures as required.

Providing Stowage Module assembly instructions

Set and Review Performance and manufacturing standards.

Monitoring and predicting usage rates.

Participating in Nutritional Experimentation.

2.3.3 Facilities

Dietetics will be located at JSC, Texas.

The Facilities will consist of :

Office Space

Computer links to other GSS elements

Training Galley

Several Computer Terminals.

2.4 Analytical Labs

2.4.1 Functions

The analytical labs perform the function of acceptance testing of incoming materials for adherence to requirements.

Secondarily, the Labs will support the GSS in the following areas: Manufacturing

Nutritional Experimentation

Inventory Control

2.4.2 Capabilities

The labs should be capable of performing analyses in the following areas: Microbiological Testing of Foods

Nutrient Assays

Performance Testing of all Incoming Materials

Physical Testing Food and Packaging Items.

2.4.3 Facilities

The labs will be required to test representative samples of a large variety of incoming food items, both for the flight warehouse and for the Ground food warehouse. This will require a considerable facility, as well as standardized analytical techniques

and a computer tie-in with the warehouses and dietetics. ~~The labs will be located at JSC, Texas~~

2.5 Flight Food Warehouse

2.5.1 Functions

This warehouse will provide Inventory Control and storage under the environmental conditions required by the food items, for the items comprising the Flight Food.

2.5.2 Capabilities

The Flight Food warehouse will be capable of performing the following activities:

- Inventory Management and Reordering

- QA Sampling

- Out-of-date Item Control

2.5.3 Facilities

The Flight Food warehouse must provide the temperature conditions required for proper storage of the food items. For the system selected in the report on Alternate Flight Food Systems Analysis, the items will all require ambient storage.

It is not expected that food items will be continuously available from suppliers, but will be ordered in quantity several times each year. Additionally, many items will be stocked and subsequently discarded if they are not chosen in sufficient quantity by flight personnel. For these reasons, the warehouse will require storage space sufficient to stock a considerable excess of food items over what would be required were free selection not available to the flight personnel. This excess is expected to diminish as dietetics acquires selection data from which to predict usage rates.

2.6 Stowage Module Assembly Area

2.6.1 Functions

This area will assemble the Flight Stowage Modules according to sequence instructions from dietetics, such that the flight personnel can remove items in their order of appearance on the flight menus.

2.6.2 Capabilities

The area must be capable of receiving and storing the necessary items prior to assembly, assembling the modules, and storing the modules prior to transport to the launch site. In addition, the personnel must make a final visual inspection of each item before assembly.

2.6.3 Facilities

This area can consist simply of a bonded area of the Flight Food warehouse. It should be sized to accommodate the stowage modules of two flights simultaneously. The flight modules will require only ambient storage.

2.7 Launch-site Module Stowage Area

2.7.1 Functions

The function of this stowage area is the storage of the stowage modules at the launch site prior to loading on board the orbiter.

2.7.2 Capabilities

This area should be capable of safe storage of the modules, with whatever temperature controls are required by the food items.

2.7.3 Facilities

This Facility could consist of any lockable portion of a building located near the launch site, assigned to the Food System. For the food items as currently defined, only ambient storage conditions are required.

2.8 Alert Crew Restaurant and Disperse Crew Galleys

2.8.1 Functions

These fixed and mobile preparation and dining facilities serve the purpose of feeding the pre-flight personnel a nutrition-controlled diet of high quality food.

2.8.2 Performance Criteria

These facilities must have the capability of feeding the pre-flight personnel on demand, wherever they might individually be located, on 24 hour notice.

The meals must be closely controlled nutritionally, and yet provide a high degree of personal choice from a large variety of items. Preparation time must be on the order of minutes, in spite of a possible lack of local facilities.

2.8.2 Cont'd

In the central location, dining should be restaurant-like, with table service.

To minimize warehousing inventory control and logistics complications, essentially the same food items should be available at all of the dining locations, with possibly some additional specialty items available at the central location for increased variety.

The choice of a dining system should not result in a system for which a large portion of its stock will remain unconsumed until it goes out-of-date. The system should also function with a minimum staff.

2.8.3 Alternate Dining Systems

The alternate systems differ in the method of preparation of the cooked food items. Selection of the preparation method determines the main features of the dining system, operations, packaging and storage of the food items.

2.8.3.1 Frozen TV Dinner

In this system, the meals are stored as frozen, pre-cooked meals, reconstituted in an oven, or possibly in a microwave.

This option would meet the performance requirements dealing with speed, simplicity and nutritional control. The variety offered by such pre-assembled meals falls short of the requirements for individual selection from a large variety of items. The food quality is lower for this option than for the other options considered.

2.8.3.1 Cont'd

The mobile units could operate adequately with butane-fired ovens and dry-ice or a phase-change freezer.

2.8.3.2 Microwavable Frozen Items

In this system, an inventory of individually packaged frozen items is maintained. Reconstitution is accomplished with microwave ovens. This option meets the performance requirements dealing with speed, simplicity, nutritional control and variety. A large inventory of microwavable foods of high quality is not currently available. This method of reconstitution differs from normal heating, and formulation and processing R & D would be required to produce items of high quality.

For this system, the mobile units would operate with microwave and dry-ice or phase-change freezers. Two potential difficulties arise for the mobile units: The possible lack of adequate power for the microwaves, and the difficulty of reconstituting in a microwave foods from a dry-ice freezer.

2.3.3.3 Boil-in Bag Frozen Items

Essentially similar to system 2.8.3.2, this system differs in that the method of reconstitution is immersion of the frozen item into boiling water while in the package. A large inventory of high quality food items in this category is available and can be enhanced with little R % D Effort. The system meets the performance requirements dealing with simplicity, nutritional control and variety. The speed of preparing food by this method is somewhat less than with the microwave, but is acceptable.

The mobile units will require butane-fired burners for the purpose of boiling water. This type of operation is completely self-contained.

2.8.3.4 Microwavable/Boil-in-Bag Frozen Items

This system is similar to system 2.8.3.2, except that the added requirement is made on the packaging that it be capable of withstanding boiling water. This requirement would add flexibility to the mobile galleys in dealing with primitive conditions. Prewarming of dry-ice frozen foods in boiling water makes them readily reheatable in the microwave. In the absence of electric power, complete heating could be accomplished in boiling water.

The R & D required for packaging is in addition to that mentioned above for microwavable food items.

2.8.3.5 Fresh-cooked Items

This is the restaurant approach. In this system, fresh foods are inventoried, and selected dishes are freshly prepared on demand by a skilled cook. This approach will yield food items of the highest quality with little need for additional R & D, and nutritional control is adequate. The system is unsatisfactory in most other respects.

There are four characteristics of efficient restaurant operations which act in direct opposition to the requirements of the Ground Dining System.

1) Time demand. Restaurants operate efficiently when the demand for service is fixed and predictable.

2) Number of consumers. Restaurants efficiently utilize their facilities only when serving a relatively large number of meals per unit time.

3) Limited Choice. A restaurant operation can only manage its inventory when the variety of offerings is restricted to a relatively few common items.

4) Fixed Facilities. A restaurant system would require a substantial investment in fixed preparation facilities. A mobile facility would be unfeasible.

The typical Family Kitchen does not share these requirements to efficient operation, but the family pays the "penalty" of having to plan its menu and acquire its inventory days in advance. This would allow little or no real-time choice in the context of the shuttle requirements.

2.8.3.5 Cont'd

Additionally, restaurant inventories are largely perishable and the alternate to restricted choice would be a high rate of spoiled food.

2.8.3.6 "Uncooked" Items

The above options are defined largely by the method of preparation of cooked items. The typical diet includes a variety of "uncooked", or unheated, food items, which would be common to all potential systems.

Frozen Desserts

A freezer is common to all of the above systems, and could accommodate such frozen items as ice-cream.

Salads

The ingredient items required for most salads are relatively few, and could be included in the inventory of the central facility and probably the mobile facilities with little effect on the efficiency of the system.

Bread Items

The decision to procure bread items locally and serve fresh to procure at the central facility and provide the items to the various galleys in the frozen state depends on the degree of uniformity required for nutritional control. Buying and serving fresh breads locally is the cheapest and simplest.

2.8.3.6 Cont'd.

Sandwich Fillings

For inventory and nutritional control purposes, sandwich fillings should be procured centrally, either frozen or thermostabilized in flexible pouches, and distributed to the various galleys.

Beverages

Beverages can be purchased and prepared locally.

2.8.4 Dining System Selection.

The Alternate Dining systems were analyzed in terms of the following categories of requirements.

Speed of Service

Simplicity

Nutritional Control

Food Quality

Food Variety

Mobile Dining Units

R & D Required

The evaluation was rated as excellent, acceptable, not acceptable. Table 2.8.4 summarizes the evaluation.

TABLE 2.8.4

Alternate Dining System Analysis

Criteria	Alternate System					
	2.8.3.1	2.8.3.2	2.8.3.3	2.8.3.4	2.8.3.5	
Speed	Acceptable	Excellent	Excellent	Excellent	Not Acceptable	
Simplicity	Excellent	Excellent	Excellent	Excellent	Not Acceptable	
Nutritional Control	Acceptable	Excellent	Excellent	Excellent	Acceptable	
Food Quality	Acceptable	Acceptable	Excellent	Excellent	Excellent	
Food Variety	Not Acceptable	Excellent	Excellent	Excellent	Acceptable	
Mobility	Excellent	Excellent	Excellent	Excellent	Not Acceptable	
R & D	Excellent	Acceptable	Excellent	Acceptable	Excellent	

2.8.4 Cont'd

The recommended system is one based on the boil-in bag method of reheating frozen food items, with the additional items of Section 2.8.3.6 available at all galley sites. It is also recommended that the added versatility of the microwave be incorporated by developing foods compatible with this method of reconstitution. This is system 2.8.3.4 described earlier.

2.8.5 Facilities

The facilities will consist of a central restaurant-like dining area at JSC, a fixed dining facility located at each launch and landing site, and mobile units to support flight personnel when not convenient to the fixed facilities.

The JSC facility should be sized for a maximum of 40 persons, and contain freezers and refrigerators for storage of Food items prior to preparation. The dining area should be designed according to typical restaurant practice. The kitchen will contain equipment consistent with Section 2.8.3.4.

The fixed Galleys at the launch and landing sites will require the same equipment as at JSC, but sized for a maximum of 20 persons. The mobile units need be sized for a maximum of 10 persons, and the dining utensils should be throw-away.

2.8.5 Cont'd

The major equipment items necessary are listed below:

Tables, chairs, Tablecloths

Surface Burners

Microwave Ovens

Cooking and Dining Utensils

Power and Water Hookups

Refrigerator and Freezer

Countertop Space

Clean-up Facilities

Storage Areas

Computer Terminal

2.9 Ground Food Warehouse

2.9.1 Functions

The functions of the Ground Food Warehouse are storage inventory control and distribution to the mobile dining units of Ground Food Items.

2.9.2 Capabilities

The Ground Food Warehouse must be capable of performing in the following areas:

Ambient, Refrigerated and Frozen Storage of Foods

Inventory Management

Coordination with Mobile Galleys

2.9.3 Facilities

It is not expected that resupply of this warehouse will be a continuous process, but will probably occur at intervals. Furthermore the demand on the system may not be altogether predictable. For these reasons, the warehouse must maintain an inventory in excess of its anticipated needs and accept the resulting waste. Temperature controlled storage rooms will be required. Computer links with Dietetics and the mobile galleys will be required.

2.10 Manufacturing Facilities

The only circumstances requiring JSC located NASA-controlled manufacturing facilities would be the inclusion of refrigerated food on-board the Shuttle Orbiter. The short shelf-life of these items prevents advance manufacture and storage of the items. These items must be manufactured continuously and at low volume, and it is unlikely that any reliable private supplies could be found under these circumstances.

Since the current Shuttle baseline does not call for refrigerated food, the Ground system will not require manufacturing facilities.

2.11 Transportation

2.11.1 Functions

Transportation is necessary to move food items and stowage modules between the warehouses and the points of Consumption.

2.11.2 Capabilities

Transportation must be capable of maintaining the temperature controls necessary for proper storage of the food items, and of rapid transit between the central warehouses at JSC and the launch sites and crew galleys.

2.11.3 Facilities

Transportation will consist of trucks for local movement, and air traffic for distance movement. Dry ice and/or phase change freezers will be required to supply the ground dining stations.

2.12 Computer Support

2.12.1 Functions

Computers will serve the data bank, record keeping and coordination functions of the Ground Support System.

2.12.2 Capabilities

The computer system must be capable of storing and manipulating a variety of data files perform record-keeping functions, allow real-time interaction to support Dietetics and provide tie-ins with the functional elements of the Ground Support System.

2.12.3 Facilities

The facilities may consist of a variety of remote terminals and a large time-shared central computer owned by a time-share company, or remote terminals and a small, dedicated mini-computer owned by the Ground Support System.

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Galley Mockup Overview
Initial Operation Configuration
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Meal Preparation Configuration
Meal Assembly
Serving
Trash Management - Day One
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Logistics
Configuration Management

Photographs and Text on the following pages present an overview and depict the functional details of a food system galley mockup conceived and designed by the Pillsbury and Fairchild Republic Companies. This semi-functional mockup was built to satisfy a required task performed under the Shuttle Orbiter Food System Study, Contract NAS 9-13138.

A twelve minute film detailing the use of this mockup to demonstrate stowage, preparation, serving, cleanup, and trash management is available upon request.

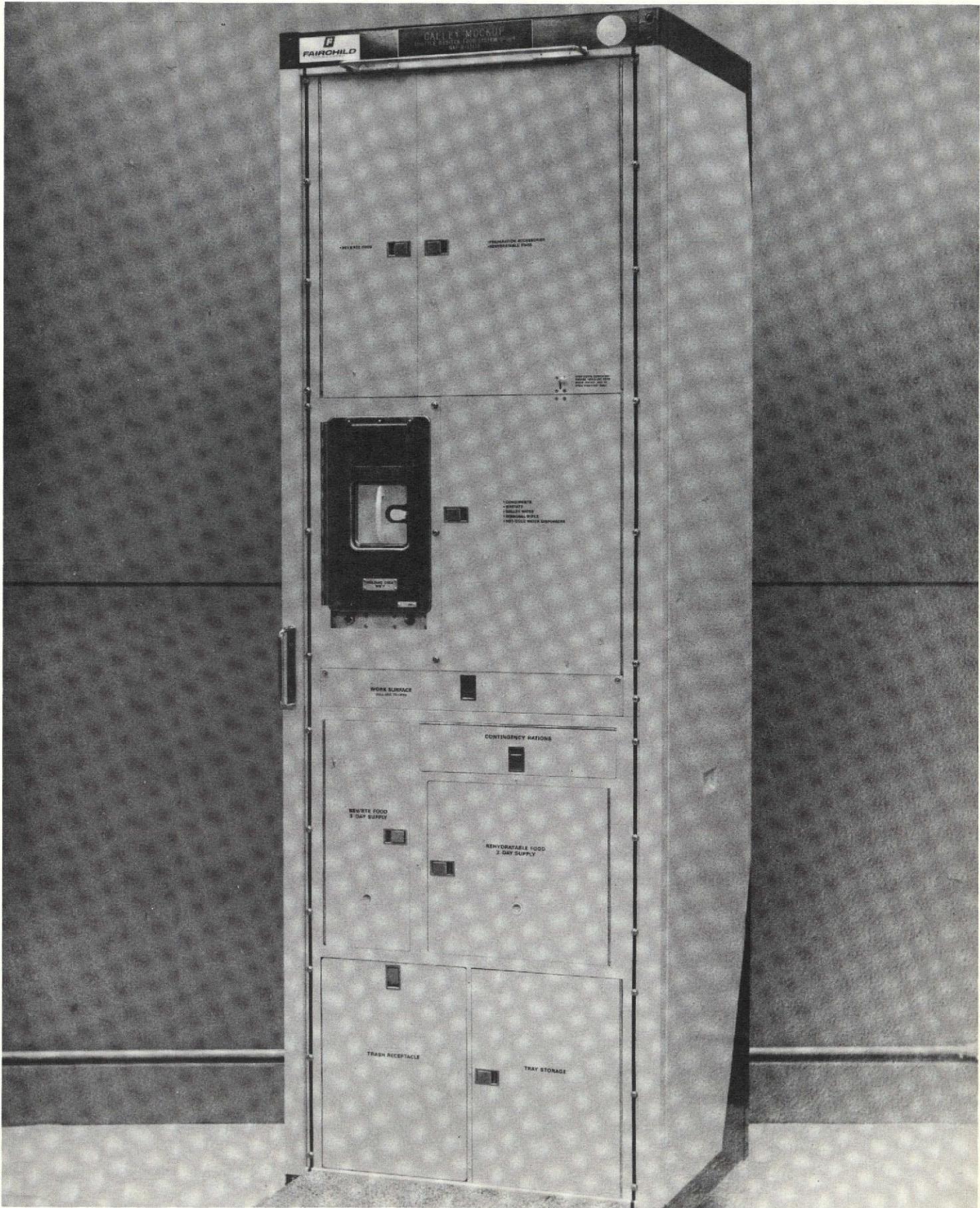
GALLEY MOCKUP OVERVIEW

- DIMENSIONS INDICATED BY BLACK BORDERS

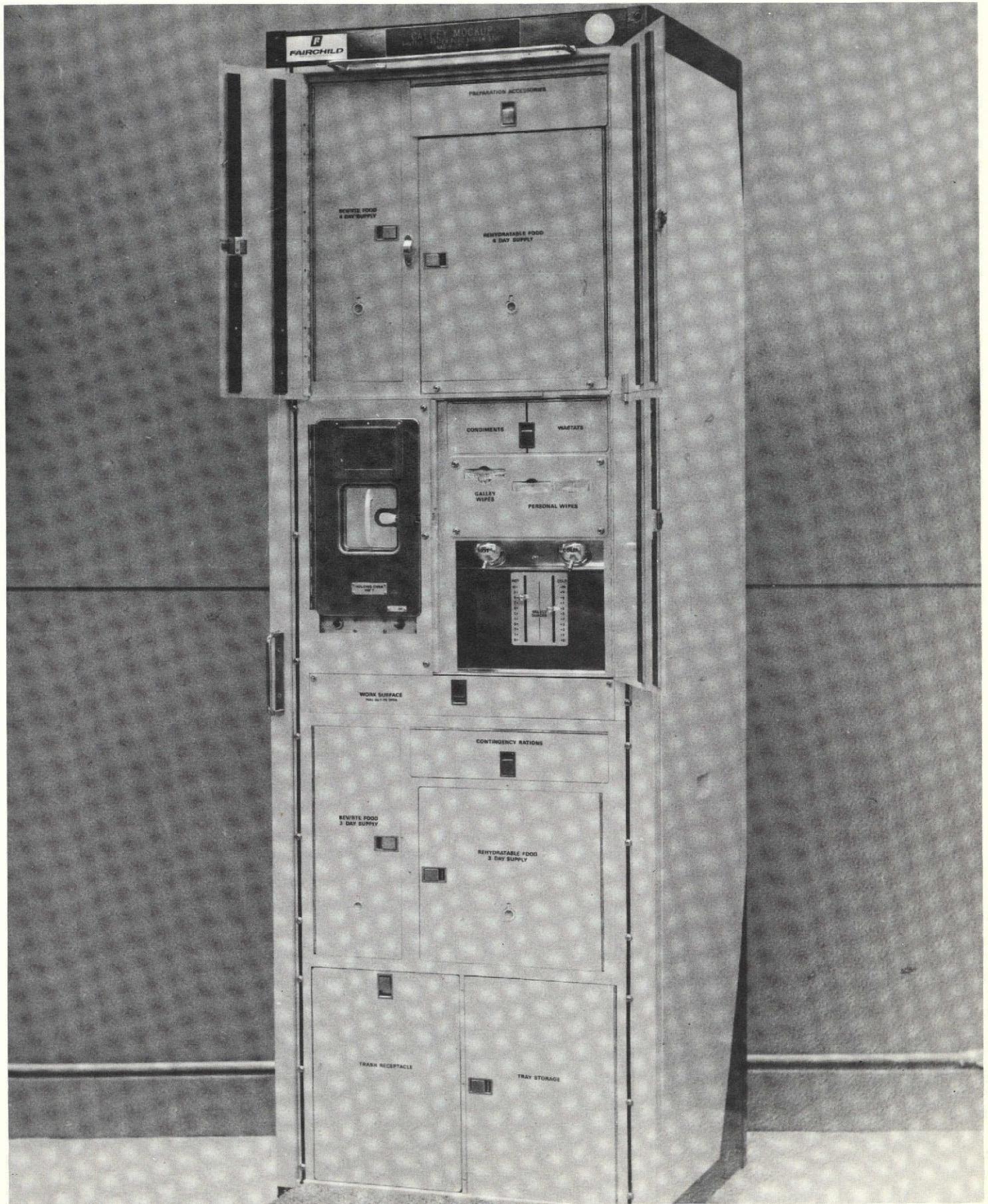
- WIDTH 23 IN.
- HEIGHT 78 IN.
- DEPTH 22 IN. CEILING
27 IN. MID SECTION
16 IN. FLOOR

- SIX MAN SEVEN DAY GALLEY IS A COMPLETELY SELF CONTAINED FACILITY FOR

- FOOD STOWAGE
- MEAL PREPARATION
- MEAL ASSEMBLY AND SERVING
- CLEAN-UP
- TRASH CONTAINMENT



INITIAL OPERATION CONFIGURATION

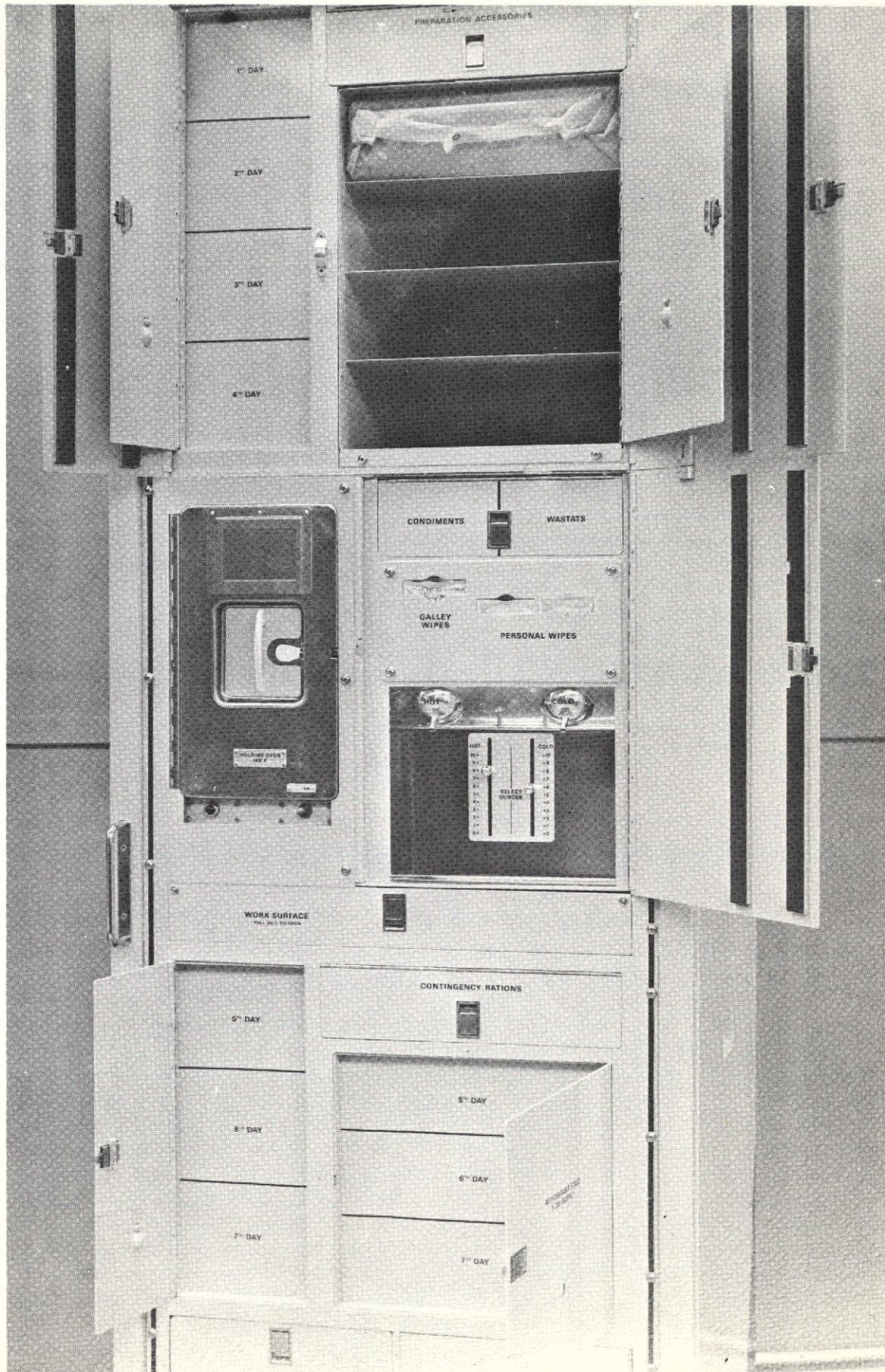


FOOD STOWAGE LOCATIONS

- FOUR FOOD STOWAGE/LOGISTICS LINERS
 - TWO REHYDRATABLE FOOD LINERS
 - TWO BEVERAGE/READY TO EAT (RTE) FOOD LINERS

- STOWAGE CONFIGURATION
 - FOUR DAY LINERS, UPPER SECTION OF GALLEY
 - THREE DAY LINERS, LOWER SECTION OF GALLEY

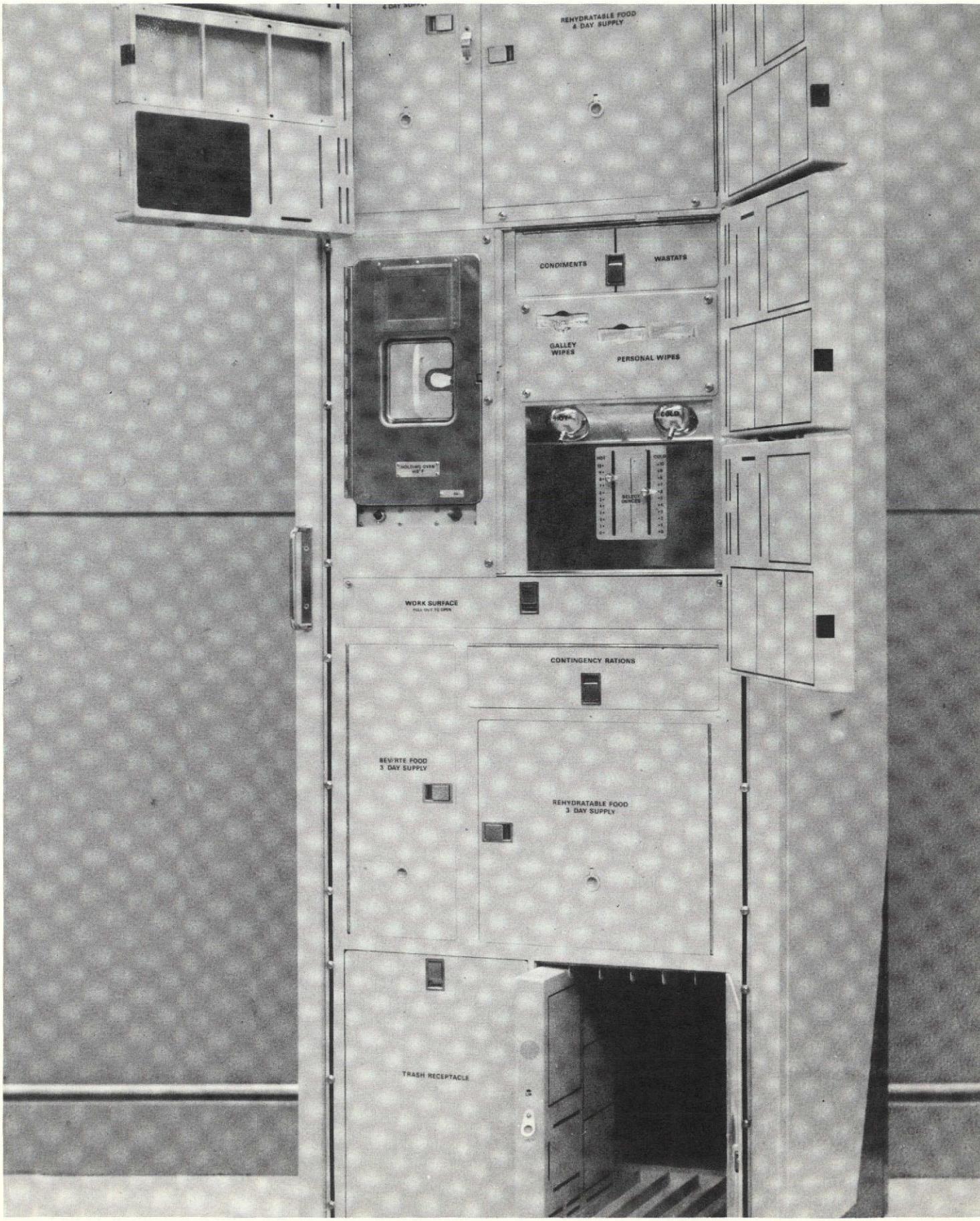
- PACKAGING CONFIGURATION
 - OVERWRAP BAG SHOWN ON DAY ONE SHELF CONTAINS CREW BREAKFAST, LUNCH, AND DINNER OVERWRAP BAGS
 - INDIVIDUAL MENUS ARE PRE-PACKAGED IN MEAL BAGS AND COLOR CODED



MEAL ASSEMBLY AND SERVING TRAYS

- TRAY STOWAGE AND USE CONFIGURATION
 - TRAY STOWAGE COMPARTMENT SIZED FOR SIX COMPLETE TRAYS
 - MAGNETIC COUPLING TO ZERO "G" WORK SURFACE DOORS

- TRAY FEATURES
 - UTENSIL STOWAGE DRAWER
 - DETACHABLE HOT INSERT TRAY
 - MAGNETIC UTENSIL SURFACE AREA
 - RETENTION SLOTS FOR RTE AND BEVERAGE MEAL COMPONENTS



REHYDRATABLE FOOD
3 DAY SUPPLY

CONDIMENTS

WASTAYS

GALLEY
WIPES

PERSONAL WIPES

HOT

COLD



WORK SURFACE
PULL OUT TO OPEN

CONTINGENCY RATIONS

REHYDRATABLE FOOD
3 DAY SUPPLY

REHYDRATABLE FOOD
3 DAY SUPPLY

TRASH RECEPTACLE

MEAL PREPARATION CONFIGURATION

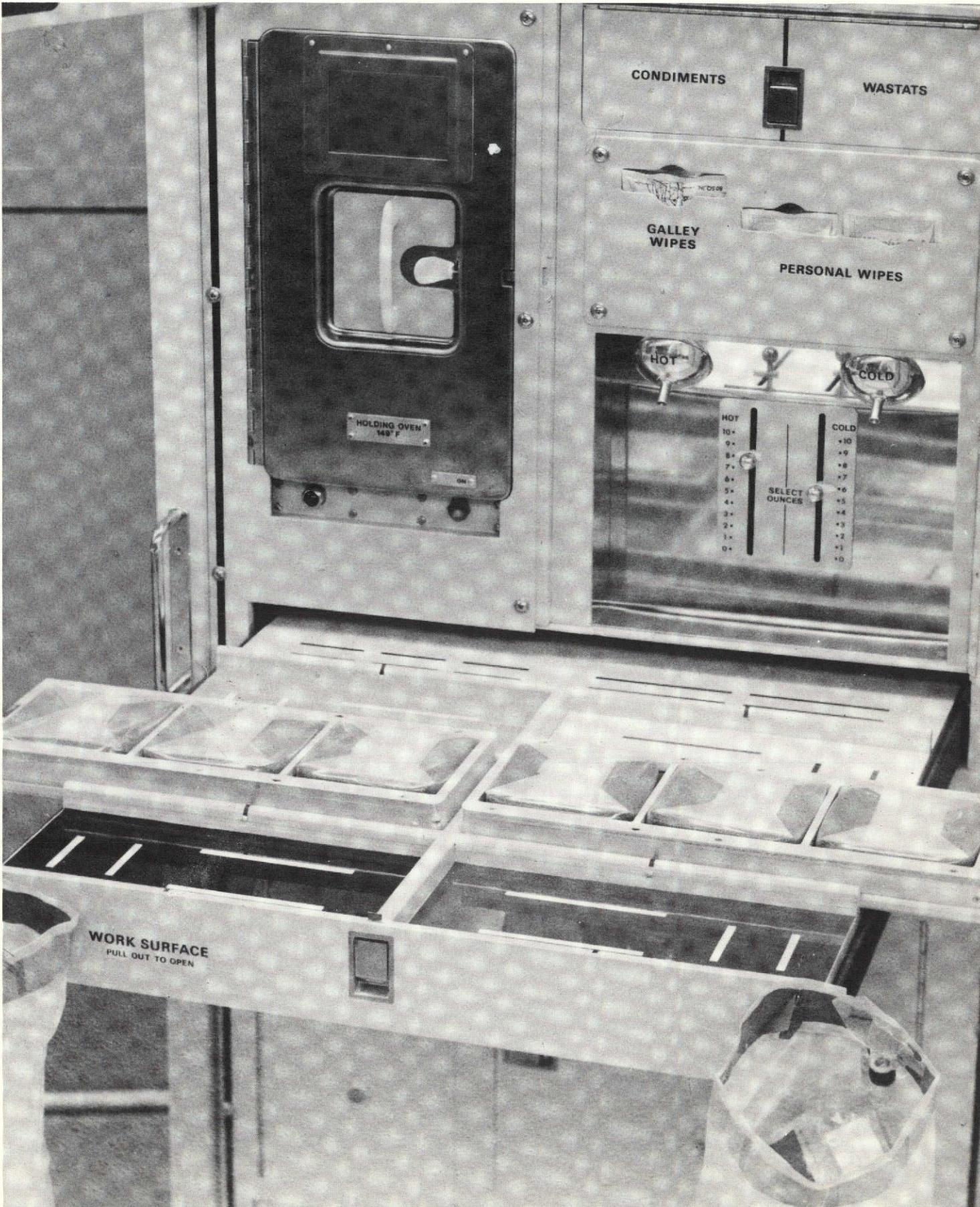
- PULL OUT WORK SURFACE FEATURES
 - POSITIVE RETENTION OF SIX HOT INSERT TRAYS
 - BEVERAGE AND RTE PACKAGE RETENTION SLOTS
 - ATTACHMENT FOR CREW MEAL BAGS
 - COLOR CODED

- REHYDRATION STATION
 - HOT AND COLD WATER DISPENSING
 - VARIABLE QUANTITY METERING

- GALLEY WIPES AND PERSONAL WIPES DISPENSERS

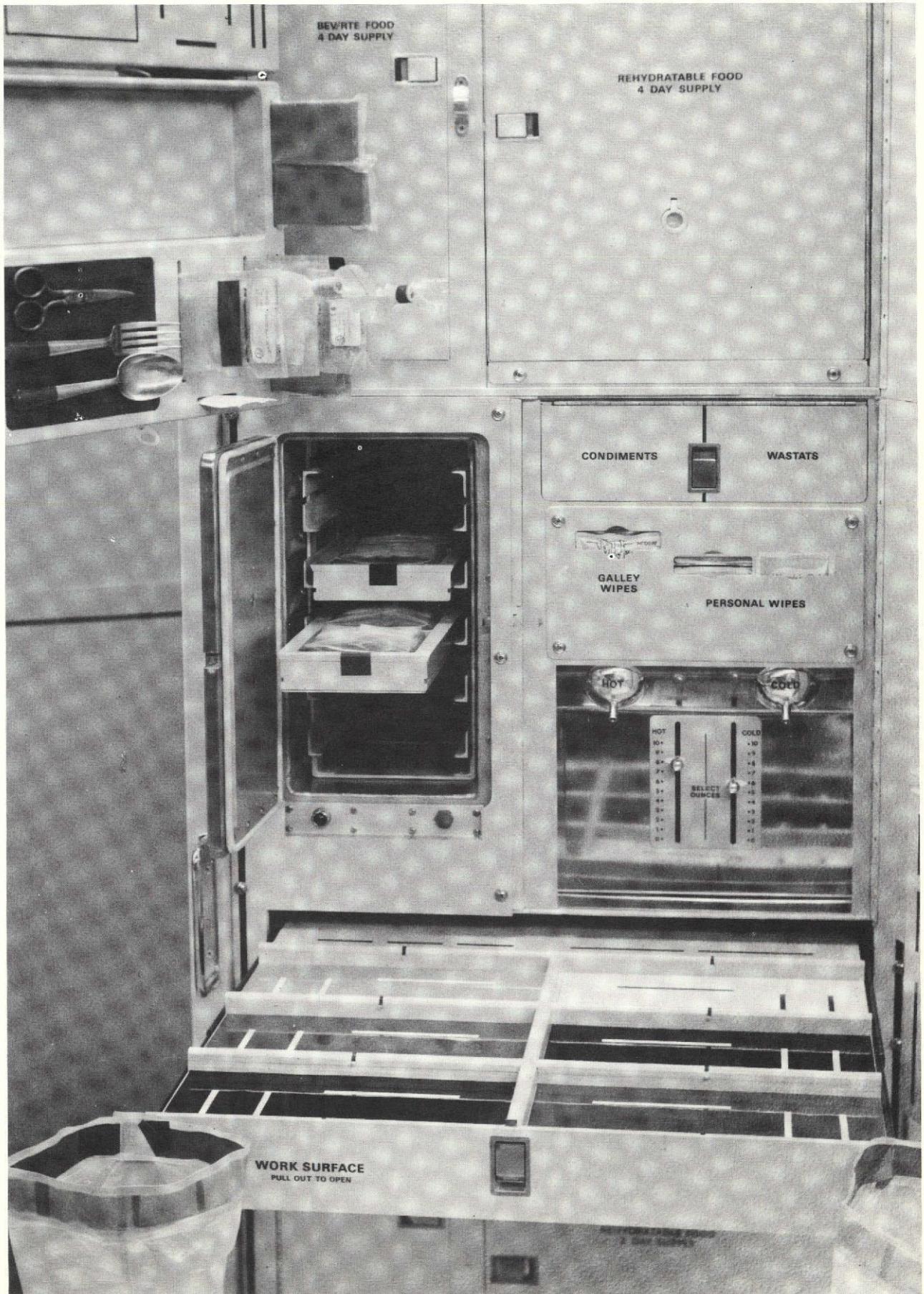
- CONDIMENTS AND WASTE STABILIZER PACKETS (WASTATS) ACCESSIBLE

- HOLDING OVEN
 - MAINTAIN FOOD AT SAFE TEMPERATURE
 - ENHANCE REHYDRATION TIME



MEAL ASSEMBLY

- HOT INSERT TRAY BEING REMOVED FROM OVEN
- MENU COMPONENTS AND ACCESSORY ITEMS ASSEMBLED ON SERVING TRAY
- EMPTY MEAL BAGS REMAIN ATTACHED TO WORK SURFACE



1944-1945

1946-1947

1948-1949

1950-1951

SERVING

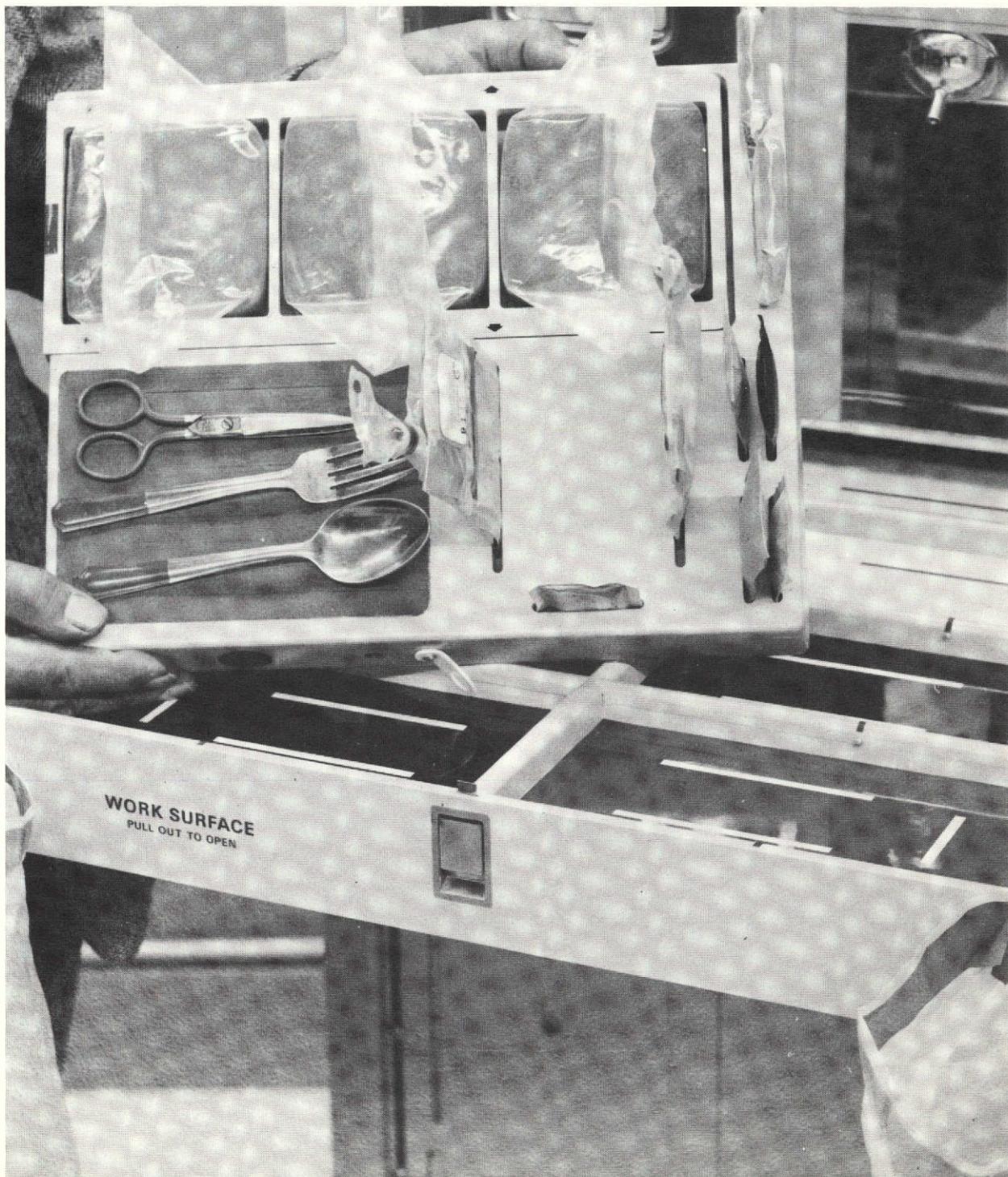
1952-1953

1954-1955

1956-1957

- ASSEMBLED MEAL ON TRAY

- 2 BEVERAGE
- 2 READY TO EAT (RTE)
- 3 CONDIMENTS AND SPICES
- 1 PERSONAL WIPE
- 1 WASTAT
- 1 SET UTENSILS
- 1 HOT INSERT TRAY WITH 3 REHYDRATABLES



TRASH MANAGEMENT - DAY ONE

- TRASH RECEPTACLE

- PULL OUT DRAWER
- ZERO "G" CLOSURE AND RESTRAINT TOP
- SIZED TO HOLD SIX SEALED BAGS CONTAINING
 - WASTE STABILIZED FOOD AND PACKAGING
 - PERSONAL AND GALLEY WIPES

BEV/RTE FOOD
3 DAY SUPPLY

REHYDRATABLE FOOD
3 DAY SUPPLY



TRASH RECEPTACLE

TRASH MANAGEMENT - DAYS TWO THRU SEVEN

- VOLUME RECYCLING

- SEALED MEAL OVERWRAP/TRASH BAGS PLACED
IN PREVIOUS DAY'S FOOD STOWAGE VOLUME

- OUTER BAG IS SEALED WHEN FILLED WITH
THREE SEALED MEAL OVERWRAP/TRASH BAGS

PREPARATION ACCESSORIES



BEV/RT

CONDIMENTS

WASTATS



LOGISTICS

51A

- LINERS

- CARRY ON FOOD

- CARRY OFF TRASH

- EXPENDABLES

- GALLEY WIPES, PERSONAL WIPES, WASTATS,
CONDIMENTS PACKAGED IN DISPENSERS
ACCESSIBLE FROM FRONT FACE OF GALLEY

- REUSABLES

- TRAYS

- UTENSILS

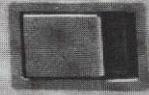
- HANDLING EQUIPMENT

PREPARATION ACCESSORIES



BEV/RTG FOOD
4 DAY SUPPLY

REHYDRATABLE FOOD
4 DAY SUPPLY



CONFIGURATION MANAGEMENT

- MODULARIZED CONSTRUCTION
- DIMENSIONAL AND VOLUME ALLOCATIONS

